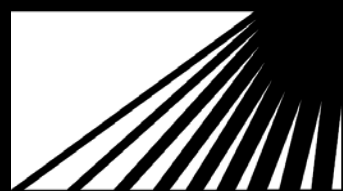


Results from the Plug-and-Play Workshop



SunShot
U.S. Department of Energy

Outline

- What are the barriers to Plug-and-Play?
 - Structural Permitting and Inspection
 - Electrical Permitting and Inspection
 - Utility interconnection and system reliability
- What are potential solutions?
- What is DOE's role?
- What are the next steps?

Electrical Safety

- **Why are inspections necessary?**
 - NEC 90.1: The purpose of this Code is the practical safeguarding of persons and property from hazards arising from the use of electricity
- **Solutions (and DOE role)**
 - UL listing for PV system: NEC 90.7 Equipment that is listed “**need not be inspected at the time of installation.**” (Simplicity)
 - Develop a **standard PV plug** at the utility meter (or elsewhere)
 - Changes to the National Electrical Code are required (we are on writing code council)
 - Smart, PV-ready circuit breakers

Structural

- **Why are structural inspections necessary? (International Building Code)**
 - Ensure the public safety, health and welfare as they are affected by building construction
 - Secure safety to life and property from all hazards incident to the occupancy of buildings, structures or premises
- **Issues:** Wind loading, system orientation, shade analysis, roof penetrations
- **DIY or Pro:** How many people would “want” to do it themselves vs. hiring someone?
- **Solutions (DOE Role)**
 - Can we build a PV system on a residential home that is
 - Light-weight (polymer)
 - Requires no roofing penetrations (can’t have roof leaks)
 - Requires few (or no) tools to install
 - Can we design a PV module/array that fits around a roof like a fitted sheet on a bed?
 - Establish requirements for solar ready houses (standardized roof jacks)
 - Consider composites, polymers... integrating frames and mounting systems can dramatically reduce weight

Utilities: Smart Grid/Communications

- **Issues to consider:** Interconnection, grid reliability
- **Small System Size:** Negligible impact? High penetration PV scenarios?
- **Solutions (DOE role)**
 - Smart grid communications with the utility for monitoring and control (e.g. SCADA/DMS integration)
 - Standard interface and protocols
 - Smart inverter that is capable of self-configuration, self-reporting, and self-healing
 - Tools for the utility to determine PV system's impact to the grid (e.g. power flow modeling)
 - Communications with the home area network (HAN)
 - Common platform for PV, energy storage, and EV
 - Multiple operation modes – grid-interactive and stand-alone
 - Tools for utility to sense the presence of PV without smart inverters (e.g. AMI meters, and grid sensors)
 - PV in mesh grid network vs. radial network

Conclusions and Next Steps

■ Conclusions

- Need to develop a UL-listed entire PV System
- Need to develop several Plug-and-Play categories and criteria
 - Electrical only
 - Electrical and grid interconnection
 - Electrical, structural, and grid interconnection

■ DOE Next Steps

- Talk with the roofing industry about possible ways to address the structural issues
- Update the white paper based on the results of the workshop

Raw Notes from Workshop

Structure

- DIY or Pro: How many people would “want” to do it themselves vs. hiring someone?
- House should be developed to work with PV – put in the right equipment ahead of time so that the electrician does not redo work
- Standard home wiring today cannot handle 5 kW PV system plugged into an existing outlet
- Customized system required for each house – no one size fits all
- Not starting from a clean slate, there is a lack of infrastructure in current roof space
- Need to design the system properly – eliminating a lot of the intermediate steps (such as permitting) by proper design will help
- We may not remove the involvement of electrician or contractor from the installation process
- Which consumer are we talking about? PV panel consumer or electricity consumers? Why not think about Plug and Play as attached to residential load – more as an off grid application
- No idea where to put it on the roof
- Proper installation is a big concern
- Wind loading, shade analysis, roof penetration, and electrical and structural combined could be a fire hazard
- Ground mount could be perceived as safer way to have solar
- Don't see homeowners climbing up on roofs to install
- Types of roof (slate...) could also be concern
- Innovative mounting techniques could be a solution

Structure

- 5 kW system weigh ~1200 pounds spread over the roof
- Water penetration into the roof is a big concern when holes are drilled to install solar panels
- Proper installation is essential – need to look for rafters in the roof
- Should be a way to install these without penetrating the roof – Self balancing systems are available but will have lateral movement
- Ballasted PV panels on the roof (one side PV panels – counterweighted on the other side of the roof)
- Require new homes to have metal tabs installed in the roof to be “PV ready”
- Flat roofs? Various existing roof architectures in older homes
- Magnetic attachments rather than roof penetration
- Glued the PV panels onto the roof
- Module integrated into the roof – thin film rollout that can be purchased at Home Depot/Lowe’s
- Interior PV in new roof builds – built-in PV in walls and shingles of homes
- Create a standard for PV installation – similar to UL, EnergyStar, LEED or ASHRAE
- Component/Panel level embedded intelligence
- Solar companies work with roofing companies to create standard racking for new roofs
- Sell new homes with a small amount (1 kW) of solar already in them – creating an upsell opportunity
- Fast install and operation of the Plug and Play system at a neighborhood level
- Big magnets holding up solar panels
- Inductive coupling

Structure

- Structural issues for roofs
- If panel weighed less than XX, then certain inspections wouldn't be needed?
- Methods of attachment and non-uniform building codes locally
- Two permits – electrical and building
- Proper fixing to roof
- Disconnection/electrical wiring system
- Could you develop a list of approved solar installers who know what they're doing and install properly?
 - Eliminates the need for inspection/permit visits
- If it's in your house and not attached, could it bypass codes?
- Pole-mounted PetraSolar units get around certain permits
- Pre-approval for given homes built to a certain code (batch the homes based on similar structural characteristics) - a basic solar package works for all of those homes
- Can DOE work with individual consumers to push to make their own communities/AHJ more solar friendly?
- It can be done today... but it's a matter of design
 - Uniform connection points (achieved through code?)
 - Standardize modules? (like a No. 2 pencil) so that pieces can fit together easily
- Mounting is not modular
- Design a template for solar-ready roofs
- USB connector for solar modules/power electronics
- Microinverters are about 5 lbs. today... to push frequency from khz to mhz, we can shrink the size dramatically

Structure

- Mandate new homes to be “solar ready” – roof mounting provisions, central electrical conduit, enable two-way power flow, and pre-approved permits for a certain amount of solar
- Prefabricating a whole new roof with solar panel as needed with prewiring etc.
- Double paned windows with PV built in and integrated into the house power system
- Develop modular mounting
 - Integrate frames and mounting
- Design a template for solar-ready roofs (for new builds and existing buildings)
- Consider composites, polymers - integrating frames and mounting systems can dramatically reduce weight
 - Reduces permitting costs
 - Non-metal materials change your grounding requirements

Solutions for Electrical Permits

- Equipment Listing: NEC 90.7 Equipment that is listed “need not be inspected at the time of installation.”
- Changes to National Electrical Code
- Simplicity: Have to make it foolproof so that the other intermediate steps become simpler
- National standards – like USB for modules, inverters, etc.

Utilities: What are the issues?

- **Interconnection:** Do utilities need to know where these are installed?
- **Grid Reliability:** Will this interfere with grid reliability
- **Regulatory:** PUCs which may need to make this process easier

Safety and Codes

- Cannot get away from the inspection process
- Concept might also work with a contractor – might make it easier for them to install and reduce costs
- Perception of risks - safety for the utility when homeowners installing their own systems (role of certification)
- Structural and fire safety issues
- Have to make it foolproof so that the other intermediate steps become simpler
- Currently no place to go to look at PV panels
- Government regulatory issues are a big part – larger utilities are regulated by PUCs which may not allow them to make this process easier without regulatory processes
- Education at all levels – consumer, utility, ...
- No clear entry point for Solar – don't know where to go
- Different codes everywhere make it harder
- A component of this is LCOE – 6-9c/kWh

Safety and Codes

- Older homes built with older codes make them not suitable to take on solar panels
- The “ConEd flowchart” needs to happen in a week (at most)
- Don’t tell me to apply for incentives; Give me the net price and send the incentive to the manufacturer
- Need to market PV like oil and gas
- New standard in the industry for homes with PV who do not want to sell to the grid – save on material, permitting
- Incent utilities to improve interconnection processes
- Streamline permitting
- Incent to establish requirements for solar ready houses
- Subsidizing Codes & Standards participation
- Common protocol for Inverter capability reporting
- Taking an active role in federal building solar installations
- National Marketing campaign: “Solar is sexy and cool”
- Solar Food Pyramid – food chain of energy consumption - “Got Solar?”
- More changes to electrical code for 2014 need to be submitted by next week (!!)
- National standards – like USB for modules/inverters/etc.
- Codes – establish clear hierarchical structure
- Consider specific applications in the micro sector
- “Move the Fence” - expanding utility-level rules to the home
- ENERGY STAR for Solar
- Shift incentive structures for permitting

Safety and Codes

- Prizes for number of solar systems installed
- Making easier for refinancing homes if they have solar
- Safety (electrical, structural) – where are skilled professionals needed?
- Liability – who pays when something goes wrong?
- Permit process itself
 - # of departments – many antiquated systems
 - Info. gaps on applications (inspectors missing info.)
 - Ability to process applications/permits
- Labor – what skill level needed? (costs, competencies – GC vs. electrician)
- Communicates: Here's what I am and it establishes itself as part of the broader utility network
- Communication can go to the permitting office
- Communications should be done using an existing communications protocol
- Interconnection agreements can go away because we are automatically collecting information
- Building codes:
 - If it attaches to the structure, may require an inspection. *Shutter model?*
 - If it sits on the ground, may not require inspection
- *Packaging should state whether the plug and play is a roof, ground or 'hang out the window' model*

Safety and Codes

- Inspection & Rebate:
 - Photo verification – report via Internet
 - Standard number of mounting configurations w/ photo verification - send digital shots to the AHJ via internet
 - List of components – standard, drop down, per unit
- Nationalize authorizations/regulations (like cars or mobiles)
- National standards
- Use all the technology tools available and apply them (irrespective of IP)
- Prioritize solar locations (co-sited with power plants, where economies of scale can be achieved, locations on the grid, etc.)
- Shape markets in the states/places that aren't using solar yet – educate the new markets for solar ... more transparency and simplicity for locals
 - Education
 - Use information/expert authority in new regions
- Consider specific applications in the micro sector
- Think of ways to bring utility scale model out to consumers/residential level
- Golden Carrot for Refrigerators (put it out to industry for a solution... ENERGY STAR for Solar)
- Shift incentive structures (easing local permitting structures)
 - Discuss broadly how can we do this? What does this look like outside today's paradigm?

Safety and Codes

- Electrical permits
 - Can we design out the possible faults that can cause electrical fires?
 - Can we define a maximum size for a negligible system?
 - Better define danger and why? (like Netherlands)
- Building permits for load on the roof
- Zoning issues (e.g. height limits)
- Historic buildings
- DOE is involved in energy codes and can stretch them to encourage PV
 - Code solutions?
 - Setting standards?
- Can a system meet codes a priori? Permitting then becomes unnecessary
 - Safety and structural integrity are the driving elements for permits
 - Can the system do this on its own?
- How much of permitting is designed to be a money-making process?
 - See Vote Solar's Project Permit (a map showing rates for AHJ permitting and time). Uses peer pressure to bring rates down.
 - Permit fees don't typically have a relationship to the actual cost of permitting
- DOE-funded system authorization (a national registry for items)...This the Regional Validation Testing (not a UL replacement)
 - Can we use these systems to go as far as entire systems up to a certain point? Get as much of the system (not just components) UL listed?
- Inspections help ID who is liable for problems (even if a city/county inspects a home, the city and county isn't liable)

Smart Grid

- Interconnection process is varied in some states
- Most current PV systems are grid-interactive only – eliminating one value proposition of using PV without grid power
- Lack of standardized connections specifically for PV
- Prep a new construction by putting in built-in conduits for PV from basement to the attic
- Need infrastructure at home to plug generation – currently designed to plug in load
- Talking about a complete change in the relationship between the customer and utility?
- TOU rates are imminent but consumers want to use as much energy as possible with fixed rates
- Consumers want fixed cost for energy – dislike the variable nature of energy costs
- Consideration for customers may not be LCOE as the first choice
- Consumers don't care where their power comes from as long as costs stay low
- A lack of education about power system costs
- It is more of a systemic education problem – solar is being continually marketed as “next generation”
- Problem – where do I go to get more information about solar
- First step for middle income groups is to Google solar but not a lot of information available
- A barrier is education about solar – especially for low income groups
- Integrated cable from micro-inverters on the PV side, to the wall outlet - Flexible sized wires based on power capability
- As you buy load, you buy generation (PV modules) and attach it to a central bus in the house
- Use plug and play electronics/communication network to inform the utility about the “state of the grid” – provide an incentive for the utilities

Smart Grid

- Polling of meters to assess status
- Utility can sense addition of PV to the grid even if the PV system is “not smart”
- Smart Meters using telephone lines to communicate to utilities
- Differing lifespans of electronics and PV modules with differing fail rates create issues for combining
- Business model of utilities leasing the roof of homeowners
- Increase customer demand for utility scale PV
- Draw and “store” PV based power in the electric vehicle at the workplace and use it at home
- Point of Sale incentives for PV
- Use “generation areas” within a neighborhood to power the “non-generation areas” - become the EV charging station for the neighborhood
- Integrated virtual net metering on multiple houses
- Get solar power from work and take it home on your car
- The “uber-box” – universal standard plug for solar, EV, etc. and interfacing with the utility
- Use the same inverter for the EV, batteries, and PV
- Simulator-based training
- Electrician time minimized by using pre-fab
- A product for DIY folks
- “Rent” panels for sometime to evaluate performance
- Wires themselves – reduce current (tech challenge)
- Mitre box – automatic shut-off for any surge
- “Smart” on both ends

Smart Grid

- Certified Pre-owned
- Pole mounted tracking on a ground-mounted PV system
- The Solar Pool Cover – Solar Canopies
- Electrical connections built into the roof racks – “SolarDock”
- Balcony PVs for apartments – sunroof shades , window shutters
- Maytag guy also installs solar arrays
- Bonus for high efficiency solar
- Utility/Grid - rates, service obligations, central control vs. distributed generation
- Lack of standardization:
 - Design/hardware/electronics
 - Codes (complex – locally specific)
 - Installation (work quality, site & component suitability)
- PV System must talk to the utility to establish a relationship to the utility
- Dedicated circuit – “smart” to prevent overloading, monitors constantly, ground fault cable
- Series of adaptors
- Smart circuit breaker – measures, monitors, communicates
- Push microinverter frequency from kHz to mHz, (reduces size)
- Consider new materials – composites, polymers
- Develop protocol to monitor PV health
- Standardize AC disconnect method

Smart Grid

- Pre-Screening
 - Systems/Modules/electronics
 - Designs
 - Structures
 - Installers
- Where can we add costs to systems to overcome technical challenges with utilities?
- Islanding homes to continue to power themselves
- Frequency regulation (add a battery)
- Arbitrage if there's real-time pricing
- If you have real power to mitigate power fluctuation, you can more realistically consider plug-and-play
- Improve time series models/simulations of PV system impact on the grid to help reduce cost for interconnection studies
 - Could you cluster interconnection studies? e.g. CAISO at the transmission level
 - Could you allow interconnection to happen and then pay for the cost of the studies and the effects on the back end, that way there's no slow down to the consumer?
- Improve autonomous regulation of systems on the distribution grid
- Improve cyber security throughout the communications network on the grid (an added cost that may increase as smart grid increases)

Smart Grid

What does the utility's grid need to do to accommodate this?

- More data exchange between PV system and utility
- Update fuses/relays for the 21st century
- Better integrate complex distributed generation
- Help with interconnection
- Improve system design of system (two way flow of energy)
- Become comfortable with a distributed rather than centralized system
- Incentives for utilities to pull plug and play systems into the structures

What do utilities want?

- Reliability of supply (power delivery)
- Right now utilities accommodate rather than pull PV onto the market
- A piece of asset ownership
- What are the pieces of a plug and play system that we could invest in to help bring us closer to making that system a reality?
- Pre-certified systems that don't require permits
- Integration of an inverter with a utility meter and AMI systems (communication)

Smart Grid

- DC-DC converter - improving safety/ARC detection/efficiency... ramping up power electronics R&D
- Module and string-level converters can help make PV systems safer
- Looking at autonomous control – inverter senses power output and reacts to mitigate effects (e.g. of power drop, frequency change)
- Have larger systems interact with the larger grid
- Having PV units report out to utilities (through AMI system)
- Functionality adds into a PV system (e.g. batteries) that enable islanding and back up system

Other Ideas/Comments

- No finished good in existence
- Product may not be designed to meet customers desires
- Customers care about savings and “looking cool”
- Does solar manufacturers guarantees expire if they are removed (due to moving, roof replacement ,etc.)
- Battery integrated into the ballast on the roof
- Full unit designed and assembled in the factory
- Rollable PV – cut to fit?
- Storage Concepts? Off Grid? – Electricity? Thermal?
- Direct DC appliances
- Plug and Play – a box with input from PV module and output of regulated power
- Add GPS to panels to self-locate
- Power electronics built-in to PV panel at the cell level
- Make everything DC
- Spray on paint based PV – depending on power level achievable and paint durability
- Determine reasonable size limits for Plug and Play PV
- Portable “SUNBRELLA”
- Mechanical – units themselves
 - Design – shape, weight, material, wiring – integrated circuitry
 - Application – functionality, suitability (can it do more than generate electricity?)
 - Compatibility with current technical parameters
 - Scale (5kv or smaller, permanent vs. temporary)
- Rollable, flexible (like tarp)
- “bee hive” – contained box mounted on pole or pad beside house
- Size limited - <250W, scalable
- Contains inverter, storage

Economics

- Almost 50% just installation labor, overhead and profit – need to reduce this
- T&D costs also need to be included – who pays?
- Cost of customer acquisition is affecting by permitting, interconnection, etc. – add more cost and time
- It has to be like buying a cellphone or calling an internet provider...as easy
- Customer acquisition cost can be brought down by overall system cost
- Price is probably the biggest entry barrier
- All you need is good FICA scores irrespective of income levels
- A general distrust about the savings potential from solarCustomer electricity bill is a crucial interface – need to separate out other power system costs from solar specific costs in the bill
- A \$50K solar system does not necessarily add \$50K to the house value – but insurance companies add that value to house insurance
- In California, there is an appreciation for renewable energy reflected in the value of houses
- Warranty should be carried over and not based on ownership
- Are warranty concerns a barrier for installing solar?
- Momentum of removing revenue from utilities
- Avoids peak power rates (Controls HVAC system – load control)
- Enables off-grid communities / homes

Economics

- Lets me go to Lowe's and buy a system that'll last for a few years with a simple installation
- Lets me own a piece of a community system (like a golf course)
- Lets me contribute to a clean world, national security, create local jobs, self-sufficient, like watching meter spin backwards
- Eases interconnection concerns so I can install it
- Reduces my peak power rate; my wife doesn't see a high electric bill
- My sculpture/garden looks good
- Reduces fossil fuel consumption, national economic benefits, independence
- Power when the grid goes down
- Mobile (for tailgating)
- Reduces amount of coal needed and looks good
- Lets me teach my kids values
- Modular pieces (piece on top of car, window shutter, mat on driveway), can install myself, can connect with my wireless technology
- Service panel has meter built in... has interchangeable part... communicates with utility... is dummy proof
- Uses contemporary solar energy... cut out the middle man – sun to panel to house... mobile... *enables* you to do other things... storage
- Saves me money, saves fossil fuels, energy independence
- Is foldable (new forms) and mobile
- Is like my TV. I can pack it up and move it out.